Apparatus and method for injection-compression molding

~~Description~~

~~The invention concerns an apparatus and a~~ method for injection-compression ~~molding~~ with a mold and a drive moving the mold. The apparatus and the method are ~~used~~ for producing molded parts, in ~~particular plastic molded parts.~~

It is known to produce molded parts by means of injection-compression molding, in which a molding composition is injected into a mold and shaped under pressure. The mold generally comprises two plates which can be moved toward one another, a negative form of the molded part to be produced being arranged in each plate. During the closing of the mold, one plate is moved toward the other plate until an opening gap or initial gap is achieved. In this position, the plates enclose a cavity. An exactly metered amount of a molding composition is injected into this cavity, either via a conventional cold runner or via a hot-runner nozzle arranged in one plate. The molding composition is subsequently subjected to pressure. For this purpose, the plates are moved toward one another until a compression gap is achieved. In this position of the plates, the cavity enclosed by them corresponds to the later molded part. For achieving a high accuracy of replication of the negative form in the molded part produced, exact maintenance of the compression gap is a fundamental prerequisite.

On account of the high internal mold pressures of over 2000 bar, the movement of the plates is carried out hydraulically by means of pistons or toggle levers. A stop is used for positioning the plates in relation to one another to the size of the compression gap. The disadvantage of these apparatuses is that the stop is soiled and is subject to wear. As a result, the plates can no longer be positioned in relation to one another to the exact size of the compression gap. These small

deviations from the compression gap lead to inferior accuracies of replication and dimensional stabilities. Deviations of several hundredths of a millimeter are consequently customary. In many cases, in particular in the case of plastic molded parts, a better accuracy of replication would lead to an improvement of the products in which these plastic molded parts are used.

A further disadvantage is that the molding composition is injected in the hot state and is subsequently cooled in the mold. The cooling causes volume shrinkages of the molded part, which likewise lead to worsened accuracies of replication. Since both plates of the mold are positioned in relation to one another by means of the stop, there is no possibility at this time of being able to intervene in the molding process.

The stop for positioning the plates is generally not arranged in the vicinity of the cavity to be filled with molding composition. As a result, the shape and position tolerances of the mold likewise contribute to a worsening of the accuracy of replication. Finally, if there are changes, or after maintenance and repair work, extensive new settings and adjustments are necessary.

Also required for the movement of the plates is a hydraulic system with one or more pumps, lines, pressure accumulators and a multiplicity of valves with the associated control. In addition, pressure intensifiers are used to assist. If the pressure has to be applied very quickly on account of the geometry, the effort is particularly great, since often relatively large amounts of oil have to be transferred and the high-speed control of the valves is very complex. Added to this is the fact that every hydraulic system involves a certain amount of leakage.

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The object of the invention is to provide an apparatus and a method for injection-compression molding which overcome the disadvantages of the prior art. With the method and the apparatus it is intended

to ensure a high accuracy of replication and reproducibility of the molded parts to be produced.

Sub A4 ~~According to the invention, the object is~~ achieved by the features ~~of Patent~~ Claims 1 and 11. ~~Advantageous~~ configurations are described in Claims 2 ~~to 10 and 12 to 16.~~

The problem is solved by an apparatus for injection-compression molding which has a mold which comprises a plurality of plates and has at least one plate on which a threaded screw drive is arranged. Assigned to the threaded screw drive via a gear mechanism is a motor, which is in connection with a control.

With the method for injection-compression molding, the plates to be moved of the mold are controlled in such a way that they can be positioned in relation to one another continuously or discontinuously.

The controlled drive of the threaded screw drive allows the plates of the mold to be positioned exactly in relation to one another in every method step during the injection-compression molding. This provides the possibility of being able to intervene in the molding process at any time.

The great advantage is that the apparatus according to the invention does not require a stop for setting the compression gap, since the positioning of the plates of the mold to the compression gap is set by means of the control of the threaded screw drive. On account of the very exact positioning capability by means of threaded screw drives, the accuracy of replication is now determined principally by the negative forms machined in the plates. This makes it possible to achieve accuracies of replication of several thousandths of a millimeter. A further advantage of the positioning of the plates by means of a threaded screw drive is attributable to the fact that these systems are not exposed to soiling effects in the same way as mechanical stops. Consequently, a very

high degree of reproducibility is achieved over very long time periods. At the same time, previously necessary readjustments are no longer needed.

The method according to the invention has the advantage that the plates of the mold are no longer moved exclusively between end positions, but instead the injection-compression molding can now be freely configured. This is made possible by the movement of the plates as desired with a high accuracy, the positioning of the plates being able to be carried out in steps of down to < 1 µm and at different speeds. With the method, process sequences in the injection-compression molding which previously could not be carried out are possible. As a result, the process can be adapted optimally to the material and the geometry of the molded part to be produced.

The movement of the plates of the mold can in this case proceed on the basis of a prescribed program or be controlled in dependence on process parameters, the process parameters being adopted in the control as controlled variables.

In an advantageous configuration, the advancement for the movement of the plates is controlled pressure-dependently. This makes it possible to avoid inaccuracies of replication caused by shrinkage, since by this method the molding composition can be subjected to a defined pressure until curing. For this purpose, the internal mold pressure is measured and compared with a setpoint value. If the internal mold pressure falls below the setpoint value, the plate is moved by a defined distance in the direction of the other plate by means of the controlled drive, whereby the internal mold pressure rises again. The defined distances may in this case be steps of fractions of a millimeter down to steps of < 1 µm. After that, the internal mold pressure is measured again and compared with the setpoint value. By repeating this procedure an appropriate number of

times, a high internal mold pressure is ensured until curing of the molded part.

Since, with increasing internal mold pressure, the power consumption of the motor for driving the threaded screw drive also increases, in a particularly favorable form of the method according to the invention this power consumption is used as a controlled variable. Use of the power consumption as a process parameter also has the advantage that it can be easily sensed and can be accessed particularly well by the control as an electrical variable.

In a further configuration of the invention, a further process parameter serving as a controlled variable for the control is the force of the threaded screw drive. This process parameter is likewise proportional to the internal mold pressure and can be determined with relatively little effort.

The positioning of the plates for the actual compressing operation can begin both after the injection of the molding composition into the mold and during the injection of the molding composition. In the latter case, it is advantageous to begin the positioning only toward the end of the injection operation.

Change [sic] in the control are also possible without any problem. The connection of the threaded screw drive to the control allows various influencing factors to be taken into account in the positioning, so that readjustments are no longer needed and maintenance intervals can be extended. As a result, the apparatus according to the invention has a high level of productivity. Setting and adjustment after repair and maintenance work can be performed with the control in a simple way and in the shortest time.

Depending on the configuration, the plate to be moved is connected either to the spindle nut or to the threaded spindle of the threaded screw drive. In the first case, the threaded spindle is driven and the plates are positioned in relation to one another by

means of the translational movement of the spindle nut. In the other case, the fixedly arranged spindle nut is driven and the positioning of the plate takes place by the translational displacement of the threaded spindle.

In an advantageous configuration, one plate of the mold is connected to a threaded screw drive. It is also possible, however, to connect two plates to one threaded screw drive each. In this way, on the one hand the mold can be opened and closed with one threaded screw drive, while compression is carried out by means of the other threaded screw drive. On the other hand, the compression may also be performed by both threaded screw drives, by both plates being designed as compressing dies.

In a further advantageous configuration, the threaded screw drive is connected to a compressing die instead of to a plate. In this configuration, the compressing pressure is not applied by the plate, but by the compressing die. The compressing die may in this case also be one or more cores, which are arranged for producing certain geometries in the mold.

In another advantageous configuration, exchangeable mold inserts which have the negative form of the molded part to be produced are arranged in the plates. In this configuration, the threaded screw drive may be connected both to the mold insert and to the plate.

Dependent on the dimensions of the molded parts to be produced, it is advantageous to connect one plate to a plurality of threaded screw drives. This allows high accuracies of replication to be achieved even in the case of large molded parts.

A further advantageous configuration is to arrange a gear mechanism, preferably a planetary gear mechanism, between the motor and the threaded screw drive for achieving the necessary high axial forces for the injection-compression molding.

Ins. A5 ~~The invention allows numerous embodiments. To illustrate the basic principle, one of these is~~

Ins. A6

described below. The associated figure shows a mold with a threaded screw drive, with a fixedly arranged spindle nut.

The apparatus for injection-compression molding comprises a mold 1, which has two plates 2, 2'. Machined in the plate 2 on the opposing end faces 3, 3' there is a negative form 4 of the molded part to be produced. Arranged in the plate 2' is a mold insert 5, in which there is machined a second negative form 4' on its side facing the plate 2. On its opposite side, the mold insert 5 is connected to a threaded spindle 6 of a threaded screw drive 7. The threaded spindle 6 is mounted in the plates 2' and 9 by means of antifriction guideways 8 in such a way that it is freely movable. A spindle nut 10, driving the threaded spindle 6, is arranged rotatably in a further plate 11 of the mold 1. The spindle nut 10 is driven via a planetary gear mechanism 12 by an electric motor 13, the rotational speed and direction of rotation of which are prescribed by a control 14. For producing a molded part, the plate 2 moves toward the plate 2', so that the mold 1 is closed, with the mold insert 4 entering the negative form of the plate 2. This position of the mold insert 4 corresponds to the opening gap. A precisely defined amount of molding composition is then injected into the cavity 16, formed by the negative form 3 and the mold insert 4, via a hot-runner nozzle 15 arranged in the plate 2. In order that the molding composition does not cool down excessively as a result of thermal conduction, heating elements 17 for controlling the temperature of the plates 2, 2' are arranged in the plates 2, 2'. After the injection, the gate 18 in the hot-runner nozzle 15 is closed by a gate needle 19. After that, the threaded spindle 6 is moved to the right by means of the spindle nut 10 to the extent that the mold insert 4 is positioned at a defined distance - the compression gap - from the negative form 3 of the plate 2. With this reduction in volume of the cavity 16, the injected molding composition is subjected to

pressure, so that the molding composition completely fills the cavity 16. The positioning of the plate in this case does not take place uniformly, but is controlled over [lacuna] by the control 14. The power consumption of the electric motor 13 is used as a controlled variable. For this purpose, the power consumption is measured. With increasing internal mold pressure, the power consumption of the electric motor 13 increases. If the measured value is less than the prescribed value, the plate 2 is moved by 1 µm in the direction of the plate 2'. After that, the power consumption is measured again and compared with the setpoint value. As long as the measured value lies below the setpoint value, the plate 2 is moved step by step. If the measured value is greater than the setpoint value, the electric motor 13 is stopped. After a certain time, the plate 2 is moved again in the direction of the plate 2' and as this happens the power consumption is measured again. These steps are repeated until the molding composition has solidified. After solidifying of the molding composition, the mold 1 is opened at its mold parting plane between the plates 2, 2' and the finished molded part is ejected by means of ejector 20.